Status of the Shortwave Surface-Only Flux Algorithms

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Twentieth CERES-II Science Team Meeting

La Jolla, California
29 October 2013

Background (Page 1)

CERES uses several surface-only flux algorithms to compute SW and LW surface fluxes in conjunction with the detailed model used by SARB. These algorithms include:

LPSA/LPLA:
Langley Parameterized SW/LW Algorithm

		Model A	Model B	Model C
SW	Clear	Li et al.	LPSA	--
	All-Sky	--	LPSA	--
LW	Clear	Inamdar and Ramanathan	LPLA	Zhou-Cess
	All-Sky	--	LPLA	Zhou-Cess

References:

SW A: Li et al. (1993): *J. Climate*, **6**, 1764-1772.
SW B: Darnell et al. (1992): *J Geophys. Res*., **97**, 15741-15760.
Gupta et al. (2001): *NASA/TP-2001-211272*, 31 pp.
LW A: Inamdar and Ramanathan (1997): *Tellus,* **49B**, 216-230.
LW B: Gupta et al. (1992): *J. Appl. Meteor.,* **31**, 1361-1367.
LW C: Zhou et al. (2007): *J. Geophys. Res*., **112**, D15102.
SOFA: Kratz et al. (2010): *J. Appl. Meteor. Climatol*., **49**, 164-180.
SOFA: Gupta et al. (2010): *J. Appl. Meteor. Climatol.,* **49**, 1579-1589.

Background (Page 2)

- The SOFA LW & SW Models are based on rapid, highly parameterized TOA-to-surface transfer algorithms to derive surface fluxes.
- LW Models A & B as well as SW Model A were incorporated at the start of the CERES project.
- SW Model B was adapted for use in the CERES processing shortly before the launch of TRMM.
- The Edition 2B LW & SW surface flux results underwent extensive validation (See: Kratz et al. 2010).
- The ongoing validation process has already led to improvements to the LW models (Gupta et al., 2010).
- LW Model C was introduced in Edition 4 processing to maintain two independent LW algorithms after the CERES Window Channel is replaced in future versions of the CERES instrument.

Status of SW Model Improvements from previous CERES Science Team Meeting

Simultaneously replacing the original WCP-55 aerosols with the MATCH aerosols, and the original Rayleigh molecular scattering formulation with an improved Rayleigh molecular scattering formulation has significantly improved the surface SW flux calculations for clear through partly cloudy sky conditions.

To account for the short term variability of aerosol properties, we have incorporated the daily aerosol properties into SW Model B.

Results for the mostly cloudy to overcast conditions showed some improvement by revising the a_0 coefficient but strongly suggest that further work on the cloud transmittance calculation is necessary. Our attention is currently focused on developing a an empirical method to account for the cloud transmittance.

Current Status of Improvements to the Surface-Only Flux Algorithms

SW Model Improvements: 1) Replacing the ERBE albedo maps with Terra maps greatly improved the SW retrievals, most notably for polar regions. 2) Replacing the original WCP-55 aerosols properties with monthly MATCH/OPAC datasets while also replacing the original Rayleigh molecular scattering formulation with the Bodhaine et al. (1999) model significantly improved SW surface fluxes for clear conditions. 3) To account for the short term aerosol variability we have incorporated daily MATCH aerosol data into Edition 4. 4) Using a revised empirical coefficient in the cloud transmission formula has improved the SW surface fluxes for partly cloudy conditions. 5) Work continues on the improvement of the cloud transmission method for the new Edition 4 clouds.

LW Model Improvements: 1) Constraining the lapse rate to 10K/100hPa (roughly the dry adiabatic lapse rate) improved the derivation of surface fluxes for conditions involving surface temperatures that greatly exceeded the overlying air temperatures, see Gupta et al. (2010). 2) Limiting the inversion strength to -10K/100hPa for the downward flux retrievals provided the best results for cases involving surface temperatures that were much below the overlying air temperatures (strong inversions).

SW and LW Model Improvements: 1) The availability of ocean buoy measurements is expected to allow for improved surface flux retrievals by providing validation over ocean regions.

Parameterized models for fast computation of surface fluxes for both CERES and FLASHFlux

Dataset	CERES 2B	CERES 4A
Clear-Sky TOA albedo Terra	48 month ERBE	70 month Terra
Clearr-Sky TOA albedo Aqua	46 month Terra	70 month Terra
Clear-Sky Surf. albedo	46 month Terra	70 month Terra
TOA to Surface albedo transfer	Instantaneous	Monthly average
Spec. Corr. Coef.	CERES 2B	CERES 3A
Cos (sza) dependence of Surface Flux	LPSA	Briegleb-type
Cloud Algorithm Terra	Terra Ed2	Terra/Aqua Ed4
Cloud Algorithm Aqua	Aqua Ed2	Terra/Aqua Ed4
SW aerosol dataset	WCP-55	MATCH/OPAC
Rayleigh Treatment	Original LPSA	Bodhaine et al (1999), JAOT.
Ozone Range Check	0 to 500 DU	0 to 800 DU
Twilight cutoff		New
Cloud transmission empirical coefficient	0.80	0.75
LW high temperature surface correction	No	Maximum Lapse Rate 10K/100hPa
LW Inversion correction	No	Maximum Inversion Strength -10K/100hPa

Recent and Future Improvements to the Surface-Only Flux Algorithms

SW Model Improvements: 1) Replacing the ERBE albedo maps with Terra maps greatly improved the SW retrievals, most notably for polar regions. 2) Replacing the original WCP-55 aerosols properties with monthly MATCH/OPAC datasets while also replacing the original Rayleigh molecular scattering formulation with the Bodhaine et al. (1999) model significantly improved SW surface fluxes for clear conditions. 3) To account for the short term aerosol variability we have incorporated daily MATCH aerosol data into Edition 4. 4) Using a revised empirical coefficient in the cloud transmission formula has improved the SW surface fluxes for partly cloudy conditions. 5) Work continues on the improvement of the cloud transmission method for the new Edition 4 clouds.

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SW and LW Model Improvements: 1) The availability of ocean buoy measurements is expected to allow for improved surface flux retrievals by providing validation over ocean regions.

Parameterized models for fast computation of surface fluxes for both CERES and FLASHFlux

Dataset	CERES 2B	CERES 4 Future
Clear-Sky TOA albedo Terra	48 month ERBE	70 month Terra
Clearr-Sky TOA albedo Aqua	46 month Terra	70 month Terra
Clear-Sky Surf. albedo	46 month Terra	70 month Terra
TOA to Surface albedo transfer	Instantaneous	Monthly average
Spec. Corr. Coef.	CERES 2B	CERES 3A
Cos (sza) dependence of Surface Flux	LPSA	Briegleb-type
Cloud Algorithm Terra	Terra Ed2	Terra/Aqua Ed4
Cloud Algorithm Aqua	Aqua Ed2	Terra/Aqua Ed4
SW aerosol dataset	WCP-55	MATCH/OPAC
Rayleigh Treatment	Original LPSA	Bodhaine et al (1999), JAOT.
Ozone Range Check	0 to 500 DU	0 to 800 DU
Twilight cutoff		New
Cloud transmission empirical coefficient	0.80	Cloud Transmission Tcod/Tccp Lookup
LW high temperature surface correction	No	Maximum Lapse Rate 10K/100hPa
LW Inversion correction	No	Maximum Inversion Strength -10K/100hPa

Lookup table to compute the SW Cloud Transmission as a function of total cloud optical depth (Tcod 0 to 75) and total cloud cover percent (Tccp 0 to 100)

Tccp Tcod	0.5	5.5	15.0	25.0	35.0	45.0	55.0	65.0	75.0	85.0	94.5	99.5
0.5	1.000	0.996	0.987	0.977	0.967	0.955	0.945	0.932	0.919	0.905	0.884	0.870
1.5	0.999	0.992	0.975	0.959	0.940	0.921	0.900	0.880	0.857	0.837	0.809	0.801
3.5	0.999	0.985	0.955	0.926	0.896	0.865	0.835	0.804	0.773	0.742	0.707	0.690
7.5	0.998	0.975	0.926	0.881	0.835	0.790	0.745	0.700	0.655	0.612	0.573	0.548
15.0	0.998	0.958	0.891	0.830	0.790	0.736	0.678	0.623	0.564	0.512	0.455	0.409
25.0	0.997	0.928	0.821	0.732	0.746	0.677	0.607	0.535	0.499	0.434	0.362	0.294
35.0	0.997	0.912	0.711	0.656	0.652	0.553	0.568	0.484	0.429	0.389	0.308	0.236
45.0	0.999	0.888	0.755	0.714	0.547	0.569	0.548	0.474	0.420	0.339	0.279	0.196
75.0	0.998	0.850	0.619	0.638	0.623	0.551	0.501	0.451	0.339	0.315	0.218	0.138

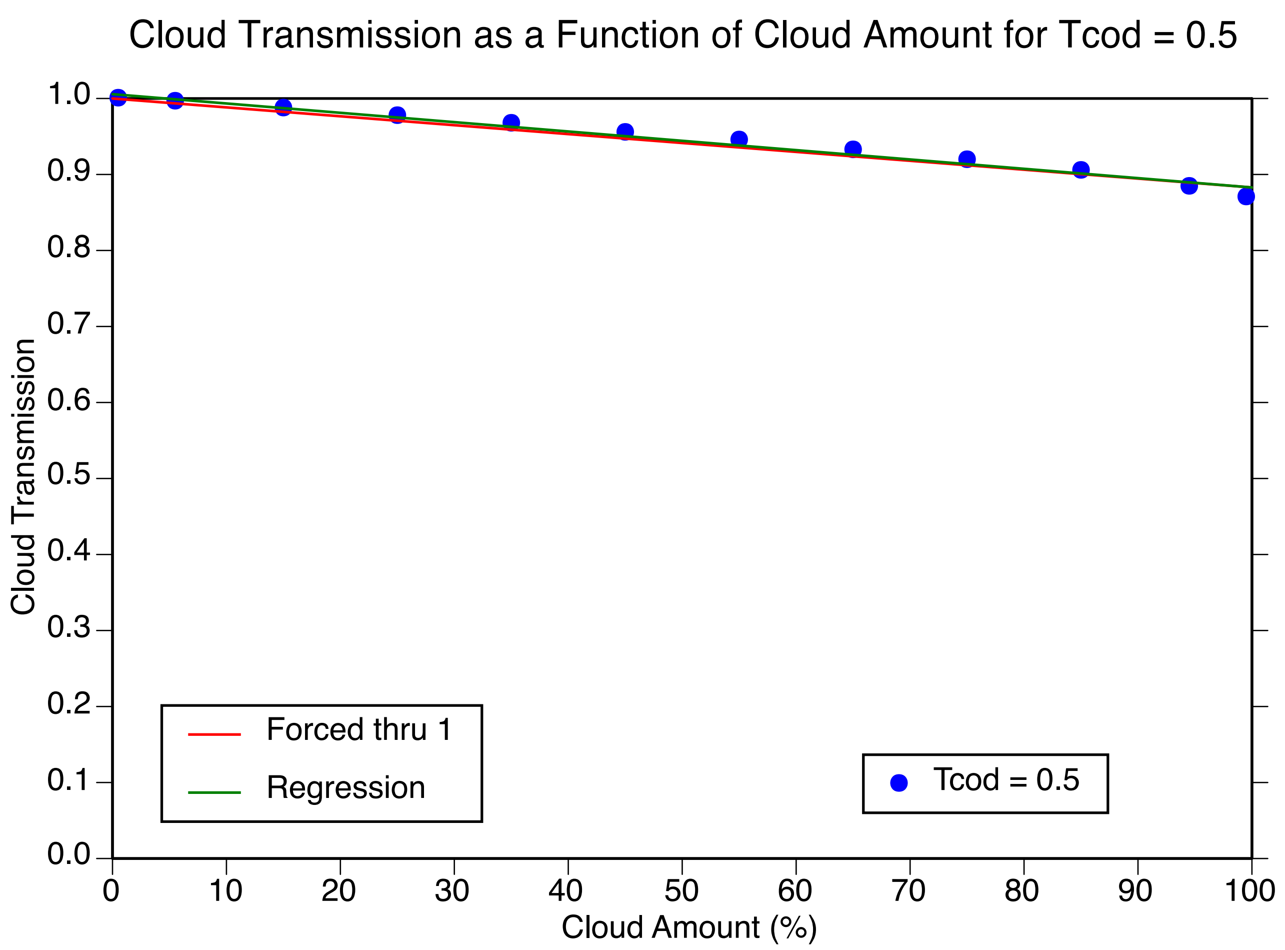
Frequency of occurrence in the Lookup table used to compute the SW Cloud Transmission as a function of total cloud optical depth (Tcod 0 to 75.0) and total cloud cover percent (Tccp 0 to 100)

Tccp Tcod	0.5	5.5	15.0	25.0	35.0	45.0	55.0	65.0	75.0	85.0	94.5	99.5
0.5	11280	24730	15686	13073	11707	10617	9703	8765	8034	7709	8564	8677
1.5	3955	11381	9552	9357	9748	10373	11135	12019	13298	15168	19492	16945
3.5	2229	7459	6321	6472	7082	8395	10677	13225	17981	27446	52192	53296
7.5	1876	4145	2843	2701	2782	3328	4037	5360	7531	12722	36686	70092
15.0	124	247	235	256	322	433	625	954	1638	3113	11630	53090
25.0	6	25	34	29	29	31	41	70	133	280	1734	15937
35.0	6	9	7	4	9	14	13	14	39	76	499	7213
45.0	3	8	4	2	3	12	10	6	10	26	210	4015
75.0	14	15	13	14	4	9	11	13	14	24	205	6548

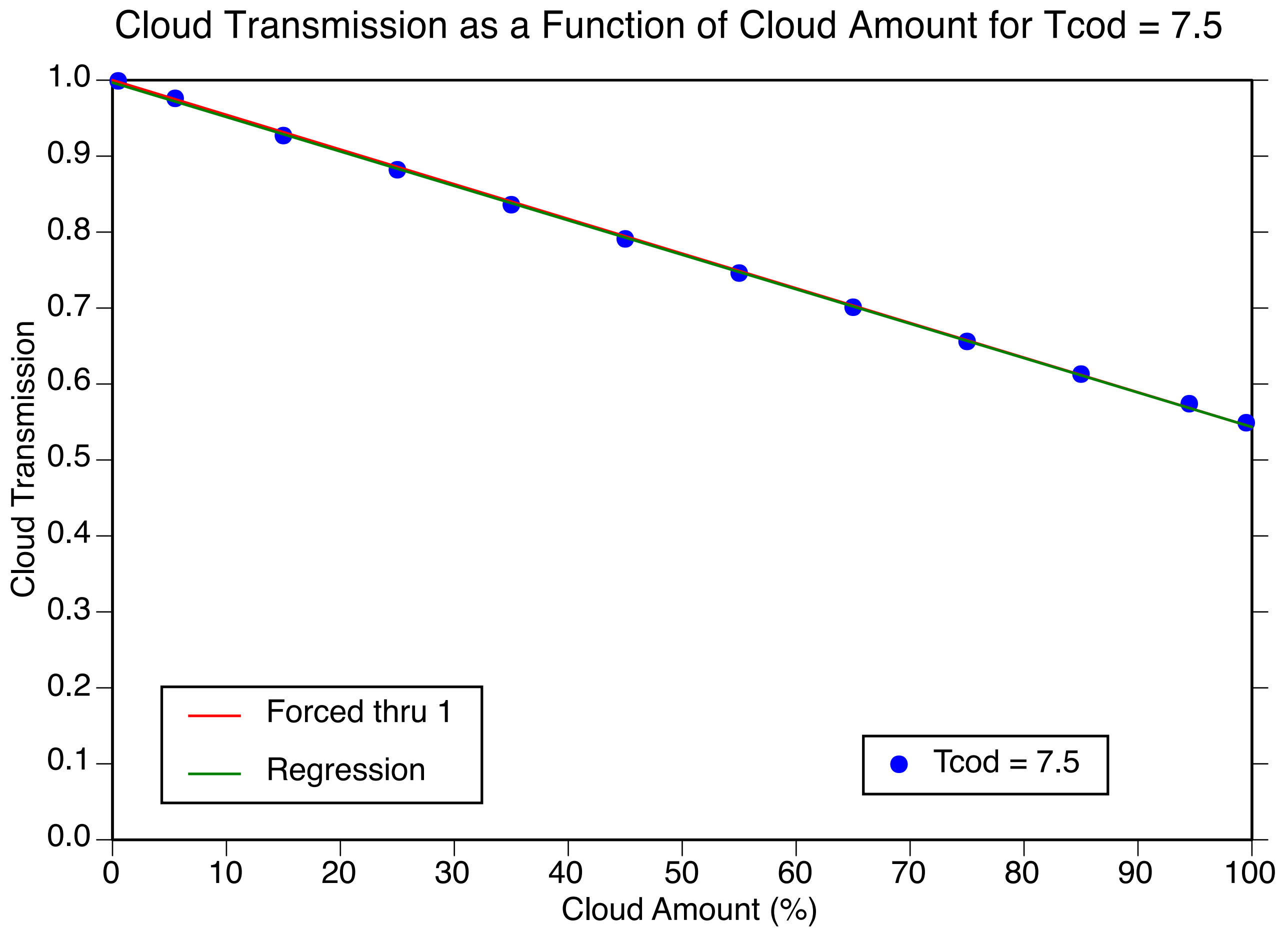
Note, a low frequency of occurrence tends to produce a higher degree of uncertainty. Thus, cases with a high frequency of occurrence should be weighted more heavily.

Standard Deviation of the SW Cloud Transmission as a function of total cloud optical depth (Tcod 0 to 75) and total cloud cover percent (Tccp 0 to 100)

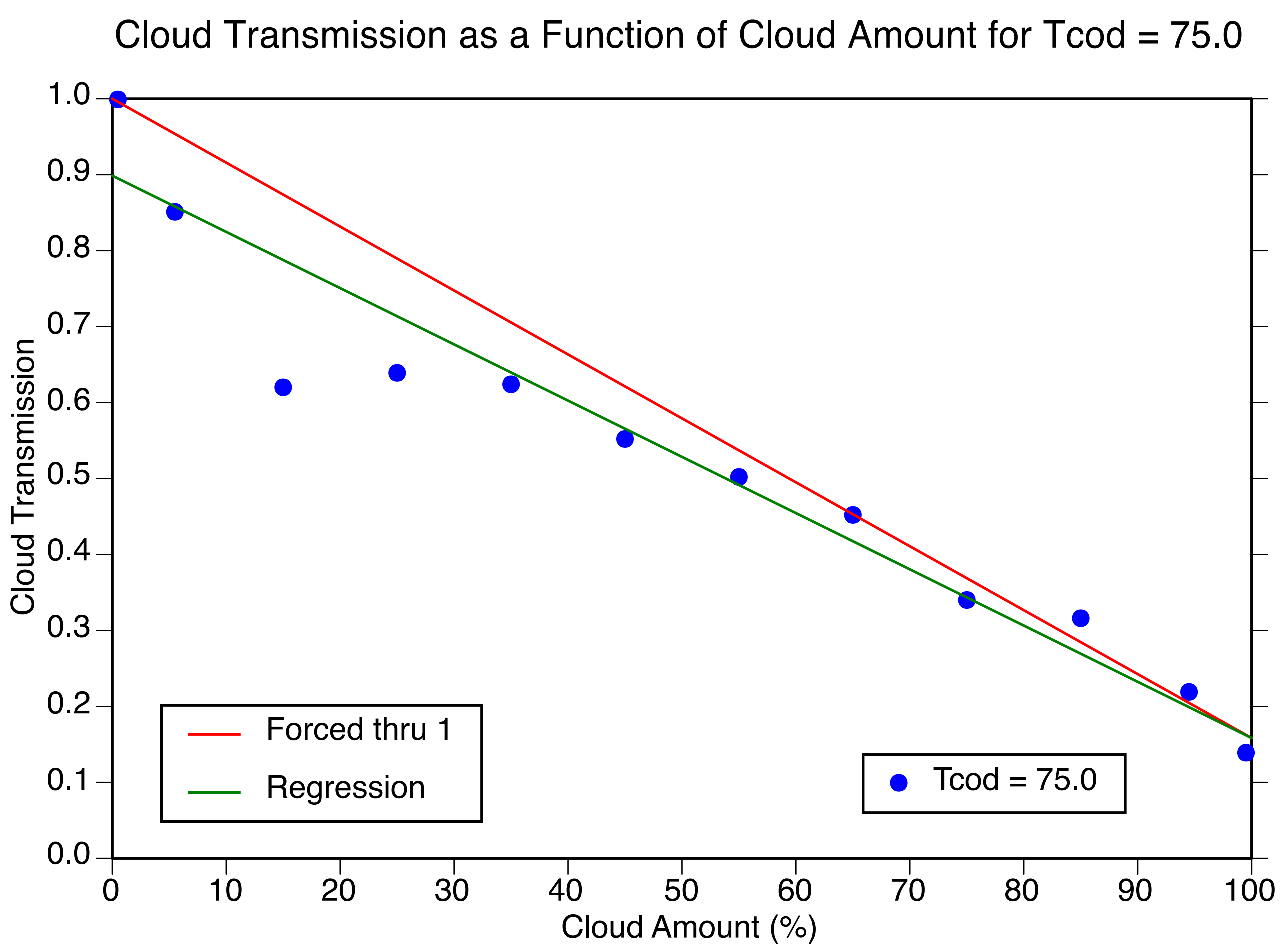
Tccp Tcod	0.5	5.5	15.0	25.0	35.0	45.0	55.0	65.0	75.0	85.0	94.5	99.5
0.5	0.000	0.004	0.009	0.014	0.019	0.025	0.029	0.036	0.042	0.049	0.059	0.064
1.5	0.001	0.008	0.013	0.018	0.024	0.030	0.037	0.043	0.051	0.059	0.071	0.074
3.5	0.001	0.015	0.021	0.029	0.036	0.045	0.053	0.060	0.069	0.075	0.082	0.087
7.5	0.001	0.020	0.025	0.029	0.035	0.042	0.049	0.057	0.066	0.077	0.090	0.098
15.0	0.002	0.057	0.063	0.058	0.050	0.051	0.056	0.059	0.067	0.073	0.093	0.097
25.0	0.002	0.090	0.121	0.076	0.071	0.067	0.055	0.059	0.075	0.081	0.098	0.082
35.0	0.002	0.143	0.156	0.154	0.110	0.068	0.059	0.075	0.055	0.091	0.111	0.085
45.0	0.002	0.123	0.150	0.144	0.095	0.071	0.087	0.086	0.061	0.054	0.121	0.089
75.0	0.003	0.202	0.188	0.139	0.164	0.077	0.052	0.056	0.055	0.106	0.100	0.095



This case has a large number of points (> 7700 points) in all of the bins.
This produces a fit with a very low overall uncertainty.



This case has a large number of points (> 1875 points) in all of the bins.
This produces a fit with a very low overall uncertainty.



This case has a small number of points (< 30) in all the bins except those with Tccp > 90. This produces a fit with relatively high overall uncertainty.

Results of Recent SW Model Development (Course of Action for the Future)

A look-up table was developed using daily averaged parameters from 4 months of SYN 1°x1° gridded data in 2004.

These parameters include: 1) All-Sky Surface SW Fluxes, 2) Clear-Sky Surface SW Fluxes, 3) Total Cloud Amounts, and 4) Total Cloud Optical Depths.

An underestimation of the surface fluxes was realized when the cloud transmission values, derived from these daily-gridded data, were applied to the instantaneous footprint level computation.

We have since revised our strategy to examine the possibility of using regression fits based upon Synoptic Intermediate SYNI data from 4 months in 2004.

Status of the SORCE Spacecraft

The Total Irradiance Monitor (TIM) was launched in January 2003 on the SOlar Radiation and Climate Experiment (SORCE) spacecraft. The TIM measures the Total Solar Irradiance (TSI), which is the spatially and spectrally integrated solar radiation incident at the top of the Earth's atmosphere. The TSI data is used to produce CERES SSF-38a.

With the loss of the CPV6 battery cell, the SORCE spacecraft is currently operating in an "emergency" mode.

Key Impacts: The TIM and all other SORCE instruments were powered off on July 30, 2013. The spacecraft instrument team will attempt to acquire TSI data using a low-power mode. Future TSI data are expected to be intermittent and of degraded quality due to thermal and pointing limitations caused by the spacecraft battery problems.

Immediate Future of TSI Measurements

Due to the reduced power available to operate the SORCE instruments, future acquisition of data will mostly be limited to periods during June and December when the satellite remains in the Earth's shadow for periods of less than 23 minutes.

SORCE will use these opportunities to perform measurement campaigns with the priority given to the TIM TSI observations to provide overlap with the TCTE mission.

While the SORCE TIM TSI data will no longer be produced on a regular basis after July, 2013, Steven DeWitte has indicated a willingness to provide the DIARAD VIRGO data in a timely manner (latency on the order of several weeks to a month); however, we will need to renormalize this data from 1363 W/m^2 to 1361 W/m^2.

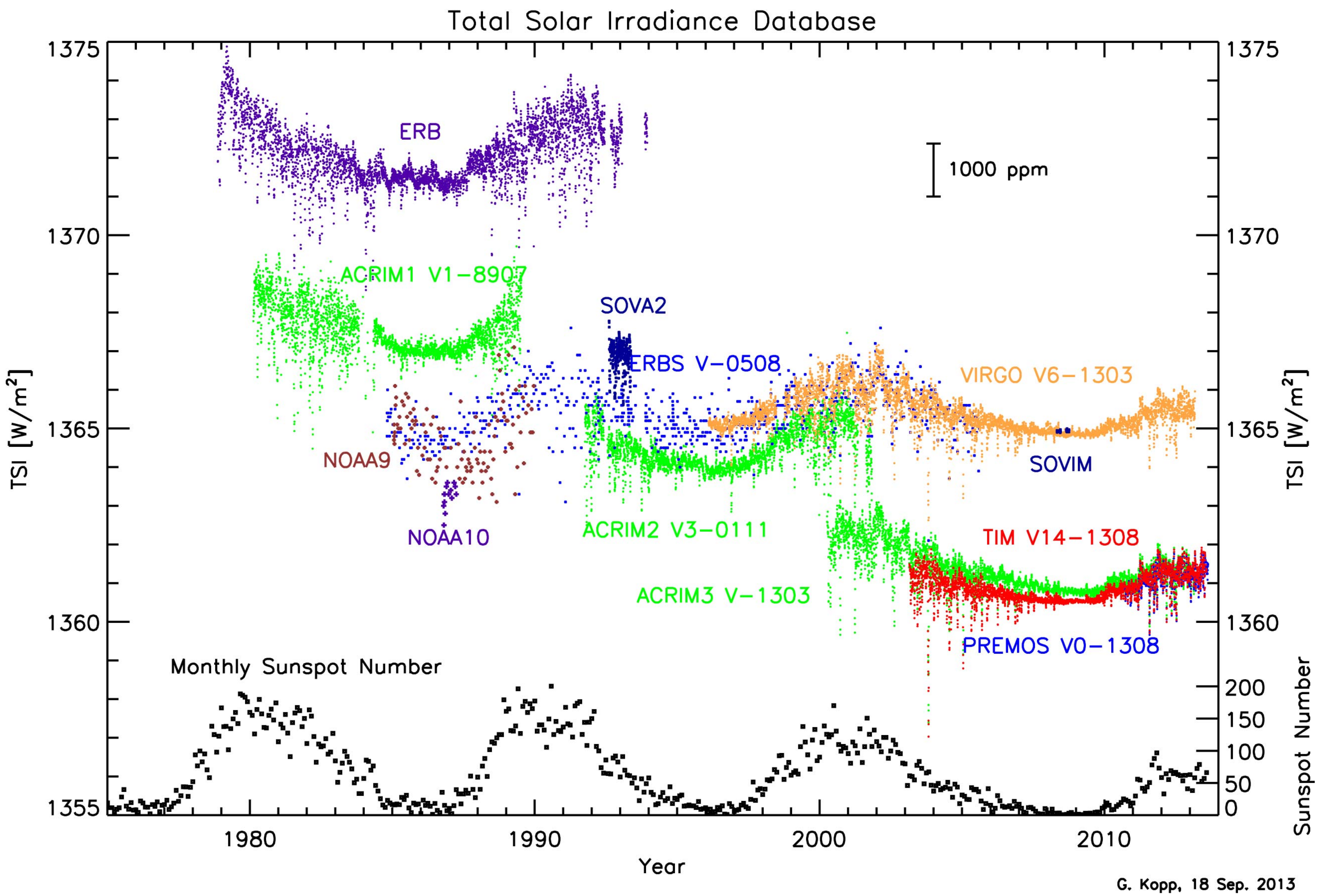
Future of TSI Measurements

The Laboratory for Atmospheric and Space Physics (LASP) has provided the flight-spare of SORCE TIM to the U. S. Air Force for use in their Space Test Program (STP) Standard Interface Vehicle (SIV) program.

The TSI Calibration Transfer Experiment (TCTE) instrument was integrated into the STPSat3 satellite, along with 4 other satellite instruments, and was delivered to the Wallops Flight Facility in Virginia on 9/6/2013 for a scheduled launch on 11/4/2013. Update 10/20/2013: Because of the furlough a new launch date has been set for 11/19/2013. According to Greg Kopp, there may be a significant time delay before the U. S. Air Force declassifies the data taken by the STPSat3 instruments.

Projected Lifetime for the STPSat3 mission is 1 year; however, STPSat2 was launched on 11/20/2010 and is still operational as of 10/2013.

Total Solar Irradiance Database, 1979 to 2013



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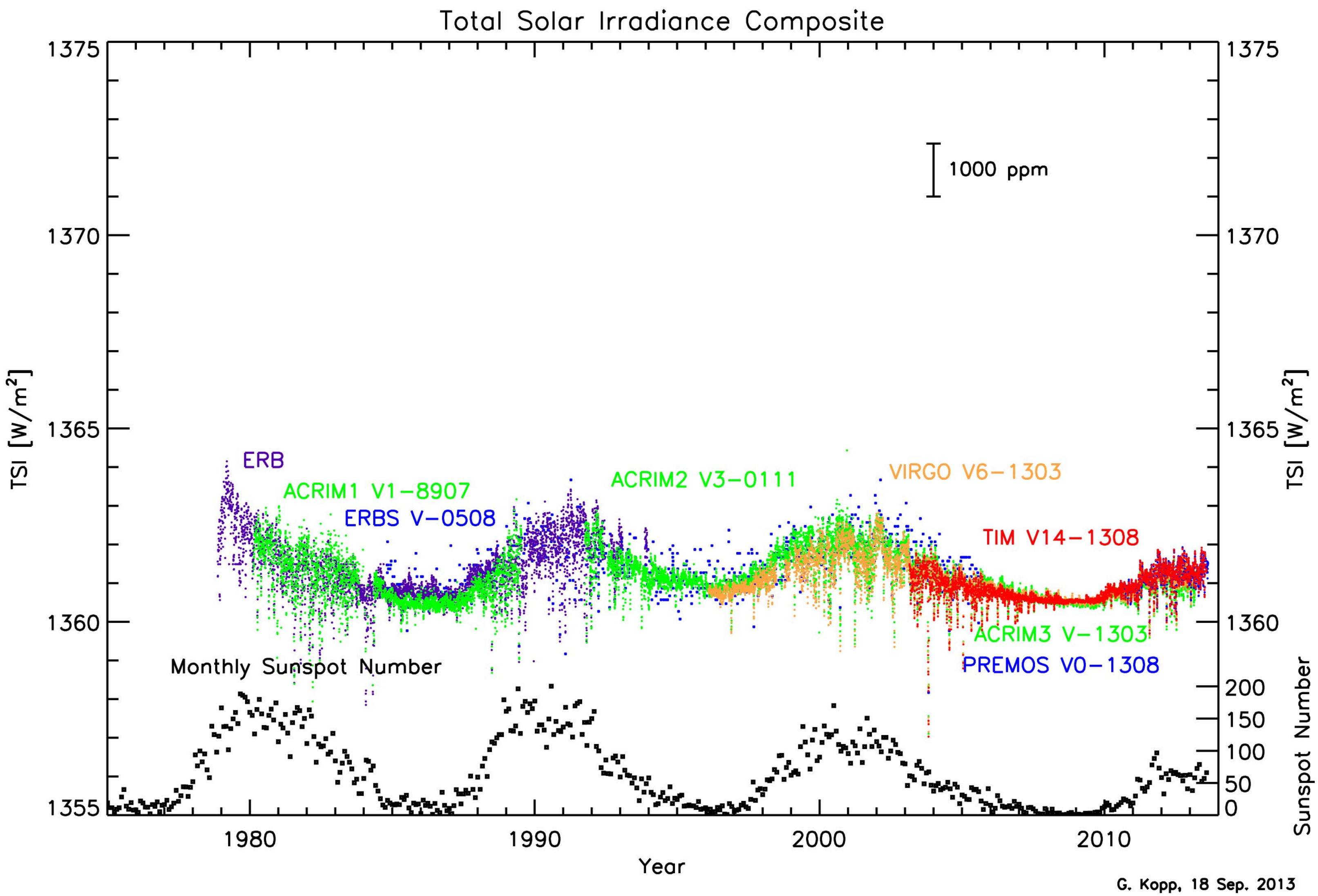
Total Solar Irradiance Database normalized to TIM V14



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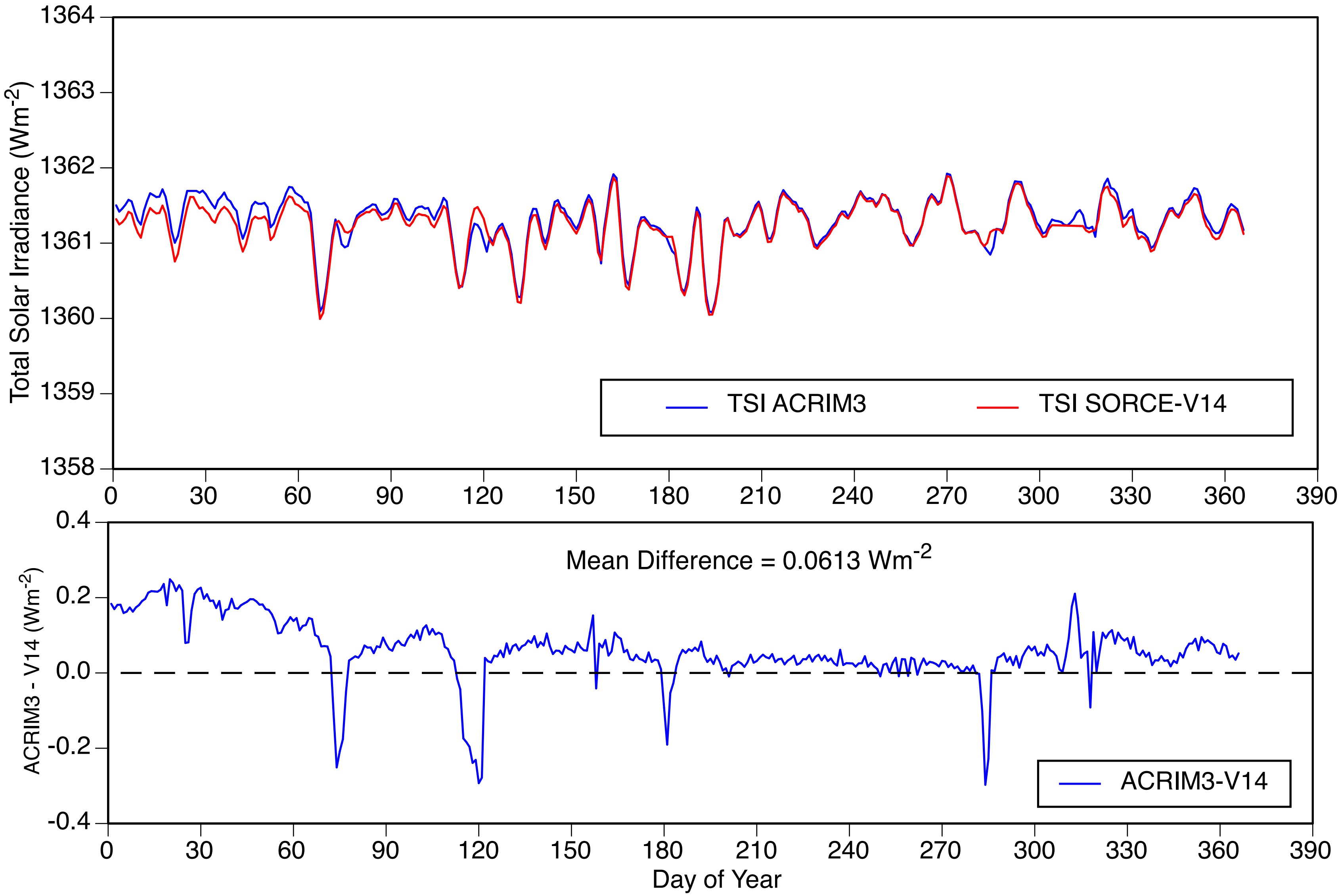
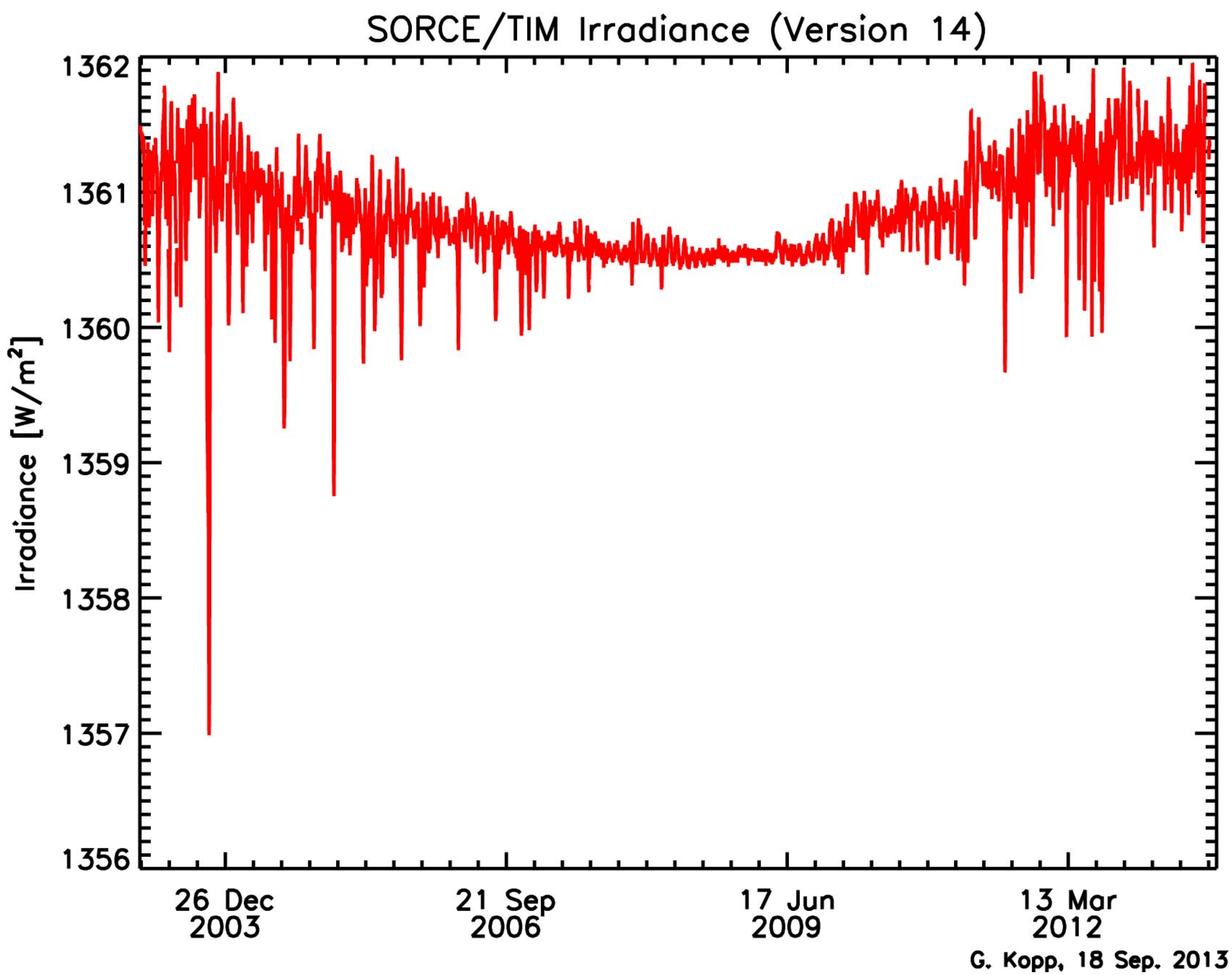
ACRIM3 and SORCE-V14 TSI Comparison - 2012





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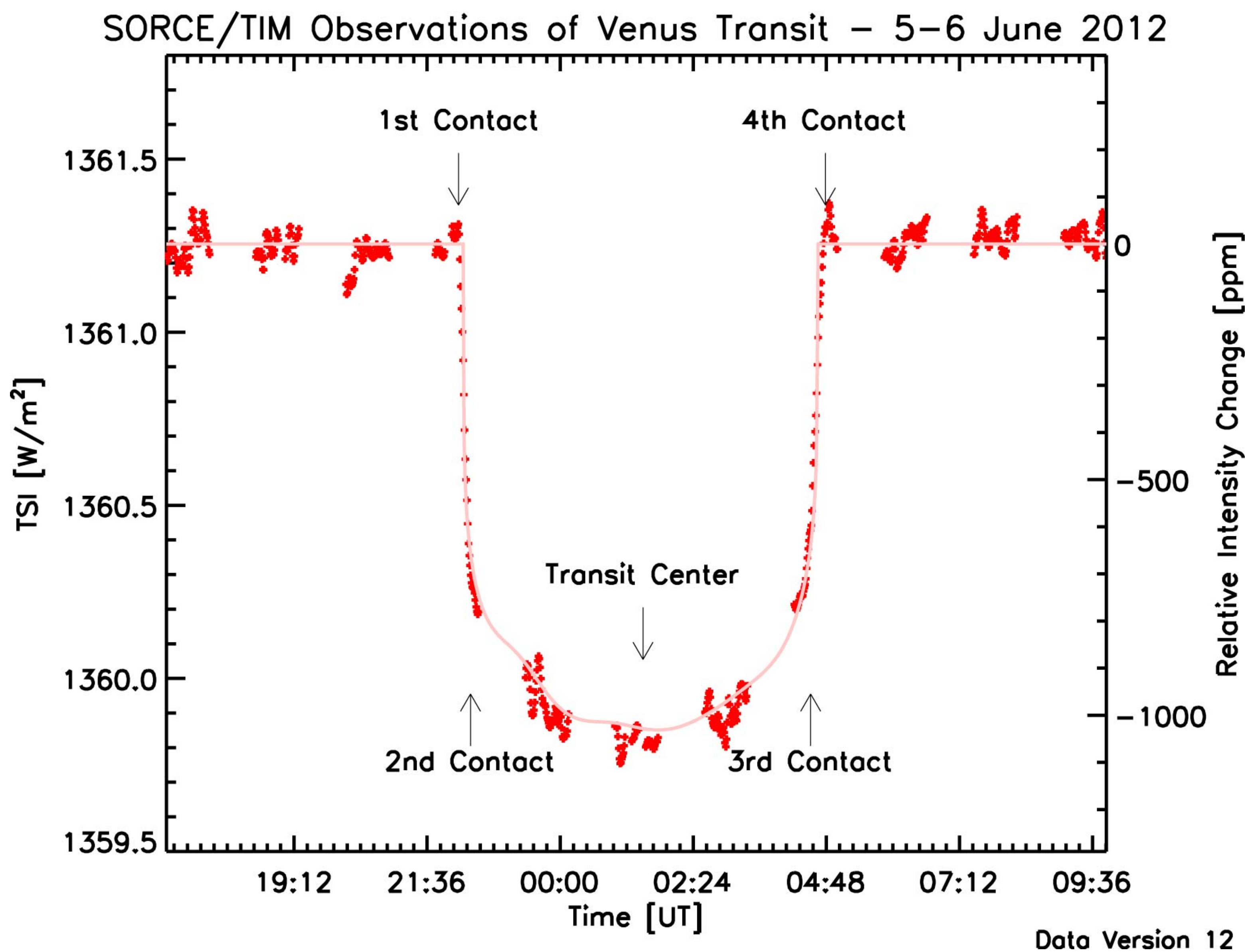

Climate Science Branch, NASA Langley Research Center

Conclusions for SOFA Ed4β algorithms

Previous validation studies have demonstrated that revisions to both the LW algorithms and the SW algorithms (for clear to partly cloudy conditions) appear to be working well, though further revisions to the cloud transmission method and/or overcast albedo method are needed for SW Model B. Currently, our attention is focused on deriving a regression fit to the data.

A preliminary analysis of the LW and SW surface only flux algorithm results using the Edition 4β inputs, especially those from the Clouds Subsystem, indicate improved accuracies for most locations.

CERES Journal Publication Citations

For all publications whether funded by CERES or using CERES data, please include the word "CERES" in the keyword list as this will facilitate listing your publication in the CERES formal publication web-page list (http://ceres.larc.nasa.gov/docs.php).

When any paper, technical report, or book chapter has either been accepted for publication or been published, please notify the CERES group of this publication by contacting Anne Wilber at (anne.c.wilber@nasa.gov).

CERES Journal Publication Citation Values (10/21/2013)

Year	All References[1]	Journal Articles[2]	Citation[3] (c1)	Citation[4] (c2)	Citation[5] (c3)
2013	79	45	38	1111	2508
2012	80	75	247	1311	2960
2011	63	63	861	1367	3086
2010	65	63	611	1143	2580
2009	49	49	785	976	2203
2008	62	61	1027	832	1878
2007	39	31	832	674	1522
2006	44	40	1469	489	1104
2005	49	47	1586	453	1023
2004	39	38	1317	347	783
2003	51	48	1718	327	738
2002	78	69	5023	303	684
2001	50	44	1982	179	404
2000	34	32	1030	179	404
1999	24	21	717	126	285
1998	20	20	2063	56	127
1997	9	9	295	33	75
1996	5	5	754	17	38
1995	1	1	17	4	9
1994	1	1	3	1	2
1993	6	6	38	0	0
Total	848	768	22413	9928	22413

Citation c1 = # of citations for papers published in that year.

Citation c2 = # of citations in ISI for papers published in all years using a specified set of categories.

Citation c3 = renormalized # of citations for papers published in all years so that the total number of citations in c3 = c1

Backup Slides Showing the Relationship for Cloud Transmission as a Function of Tccp for 9 Values of Tcod

Least-square linear fits shown:

End point (for Tccp = 100) determined by the fit.

Red lines: Tccp = 0 point forced through 1.

Green lines: Tccp = 0 point – intercept value provided by the fit.

Frequency of occurrence in the Lookup table used to compute the SW Cloud Transmission as a function of total cloud optical depth (Tcod) and total cloud cover percent (Tccp)

Tccp Tcod	0.5	5.5	15.0	25.0	35.0	45.0	55.0	65.0	75.0	85.0	94.5	99.5
0.5	11280	24730	15686	13073	11707	10617	9703	8765	8034	7709	8564	8677
1.5	3955	11381	9552	9357	9748	10373	11135	12019	13298	15168	19492	16945
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75.0	14	15	13	14	4	9	11	13	14	24	205	6548

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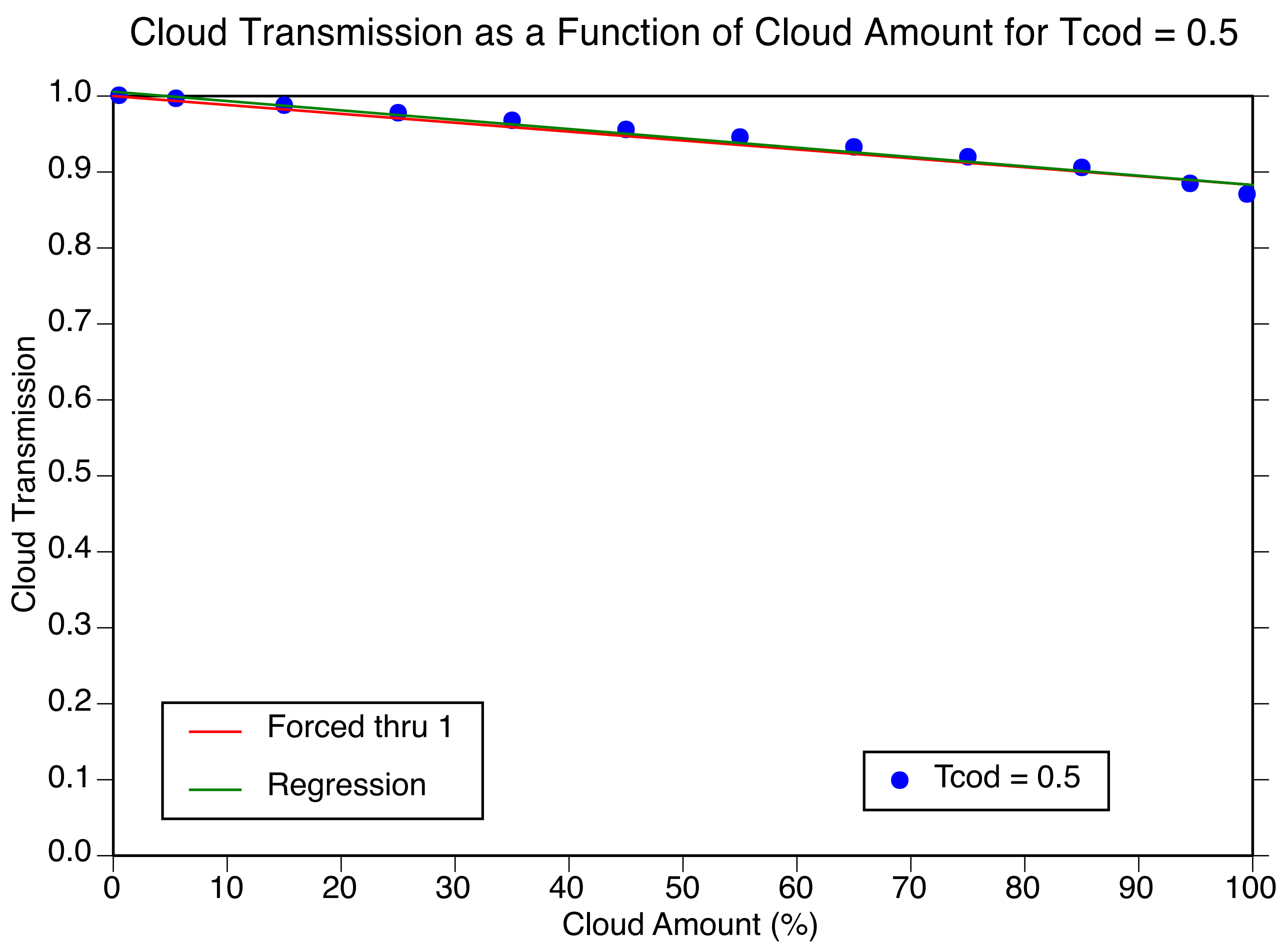
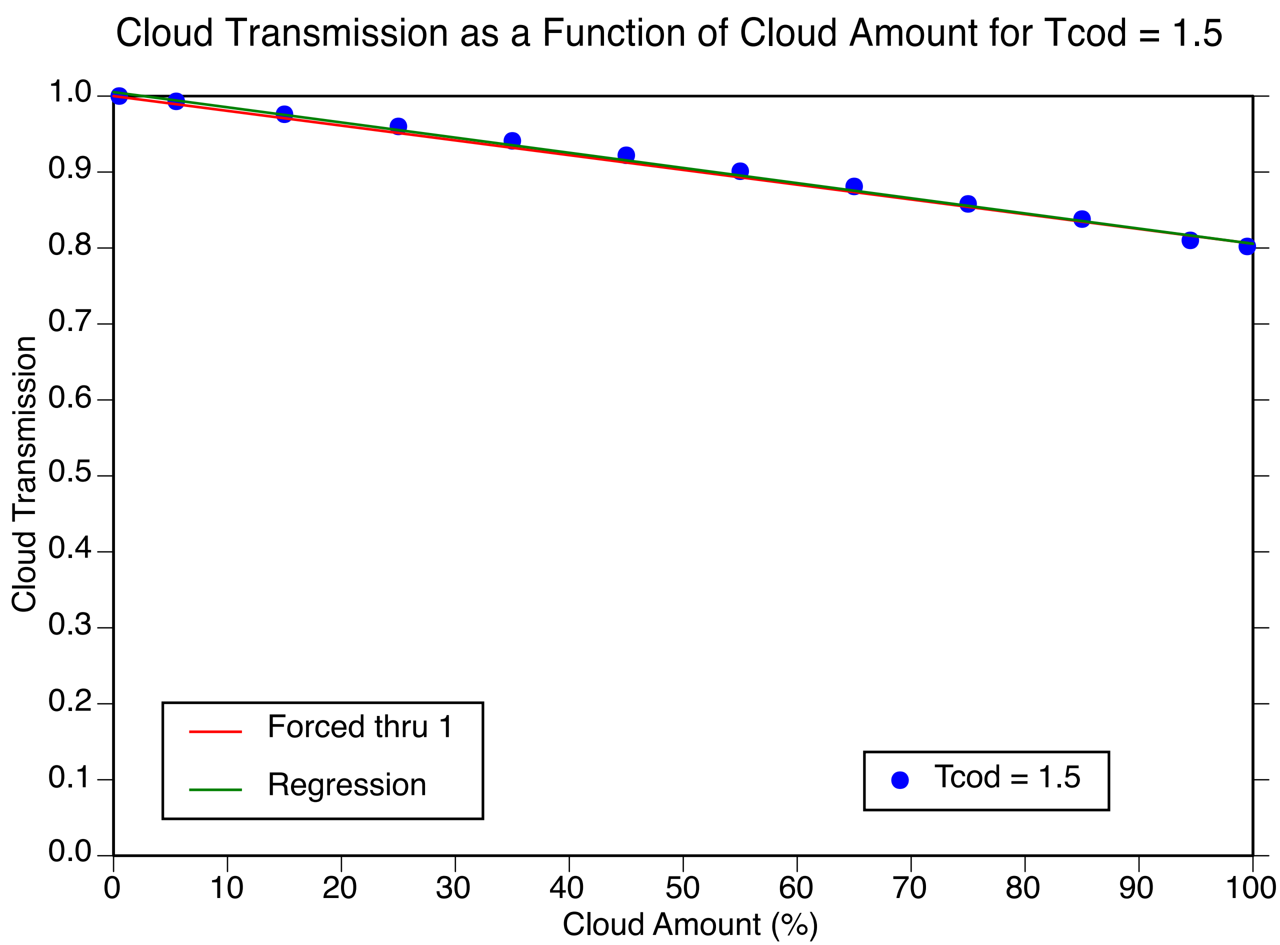
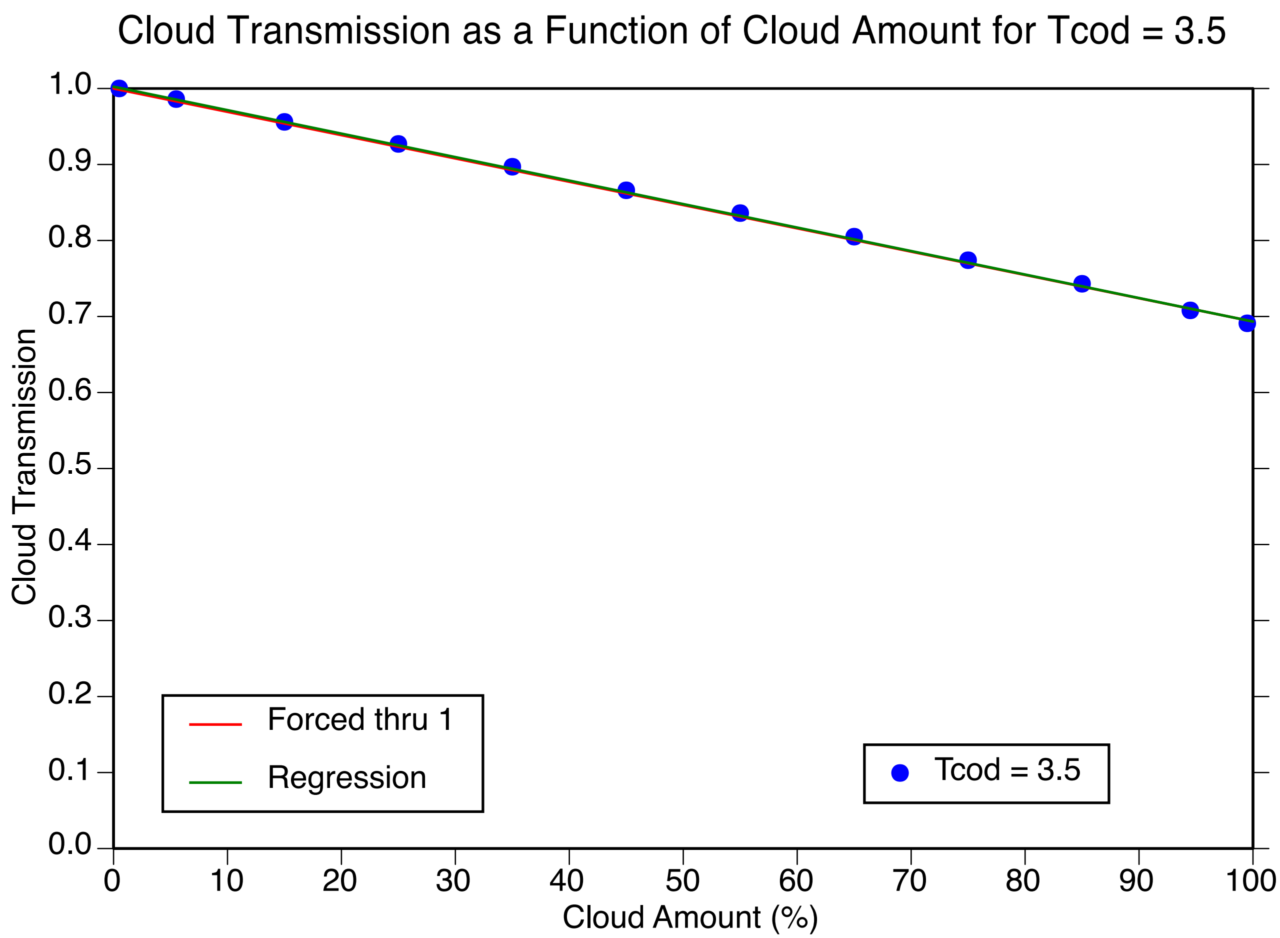
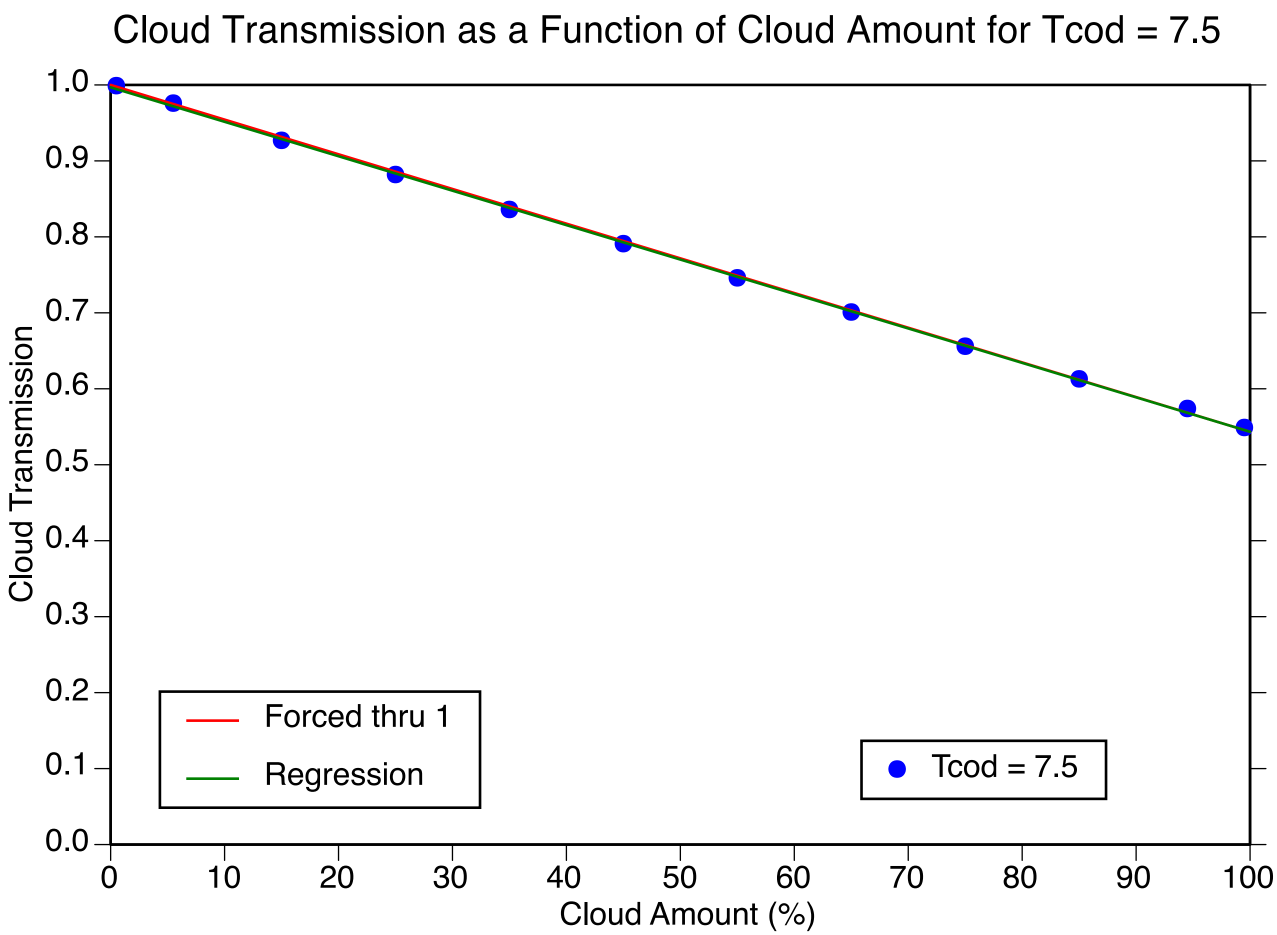


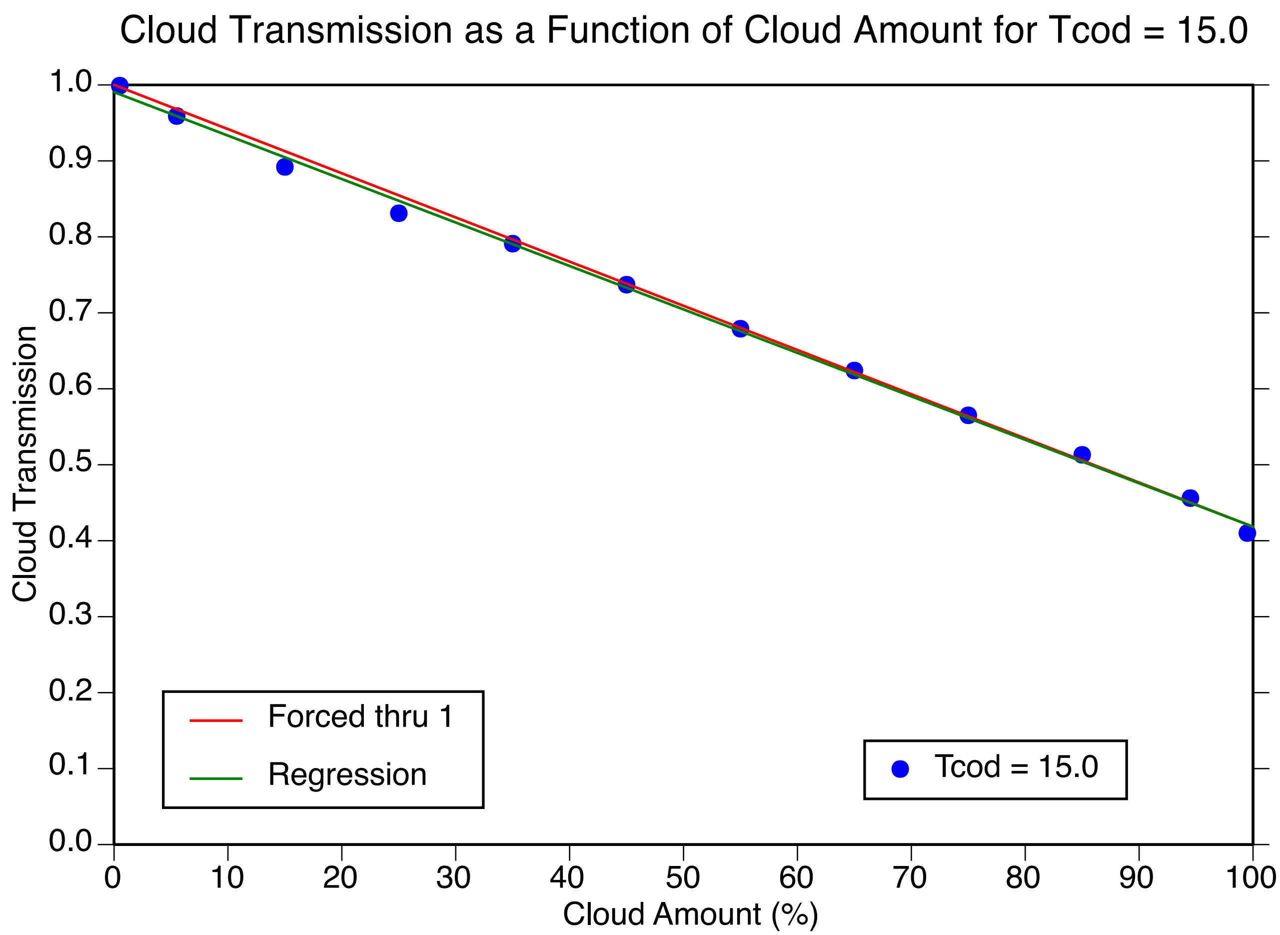
Cloud Transmission as a Function of Cloud Amount for Tcod = 0.5
Cloud Transmission
Cloud Amount (%)
Forced thru 1
Regression
Tcod = 0.5
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100



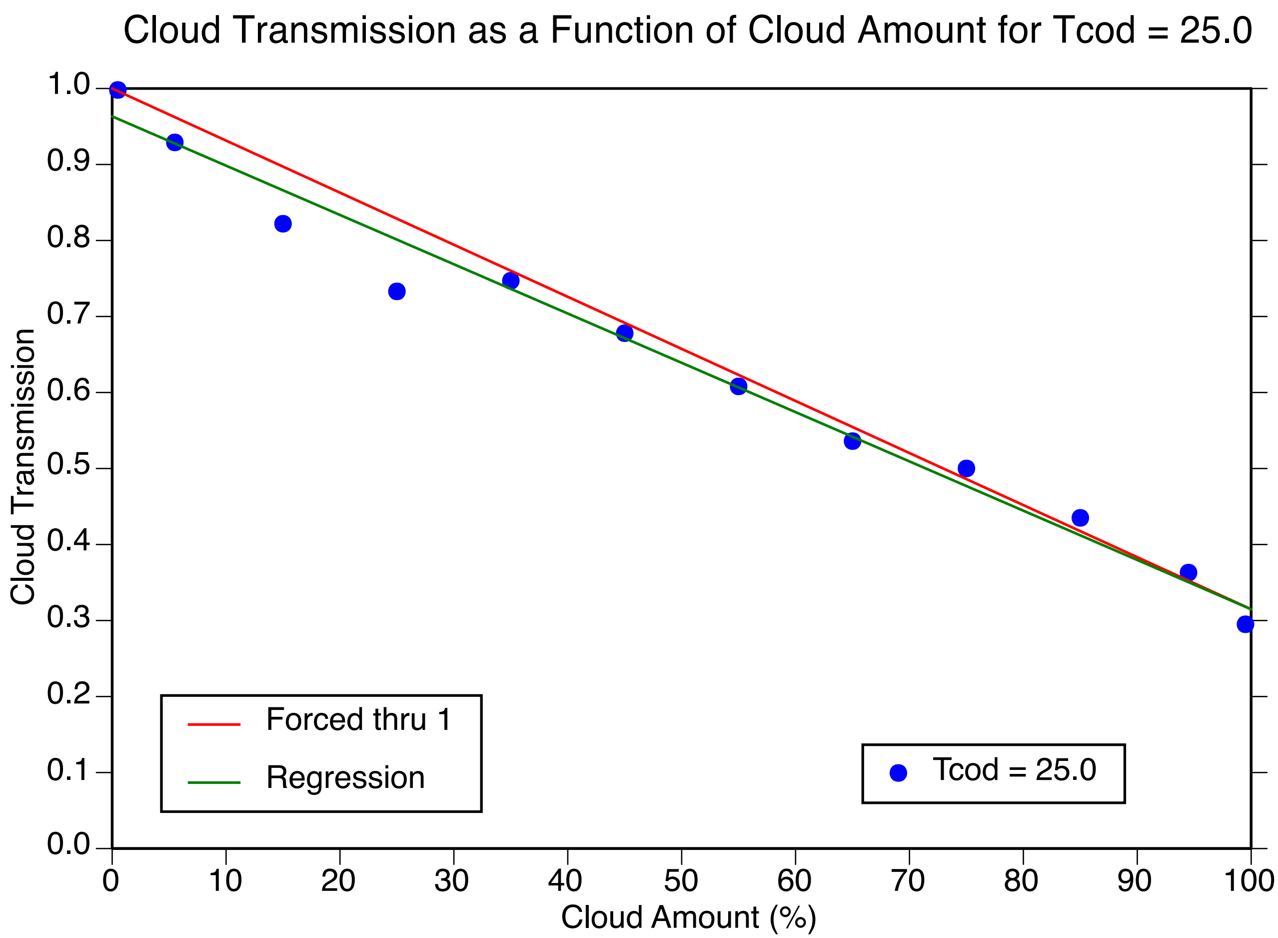
Cloud Transmission as a Function of Cloud Amount for Tcod = 1.5
Cloud Transmission
Cloud Amount (%)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0
10
20
30
40
50
60
70
80
90
100
Forced thru 1
Regression
Tcod = 1.5

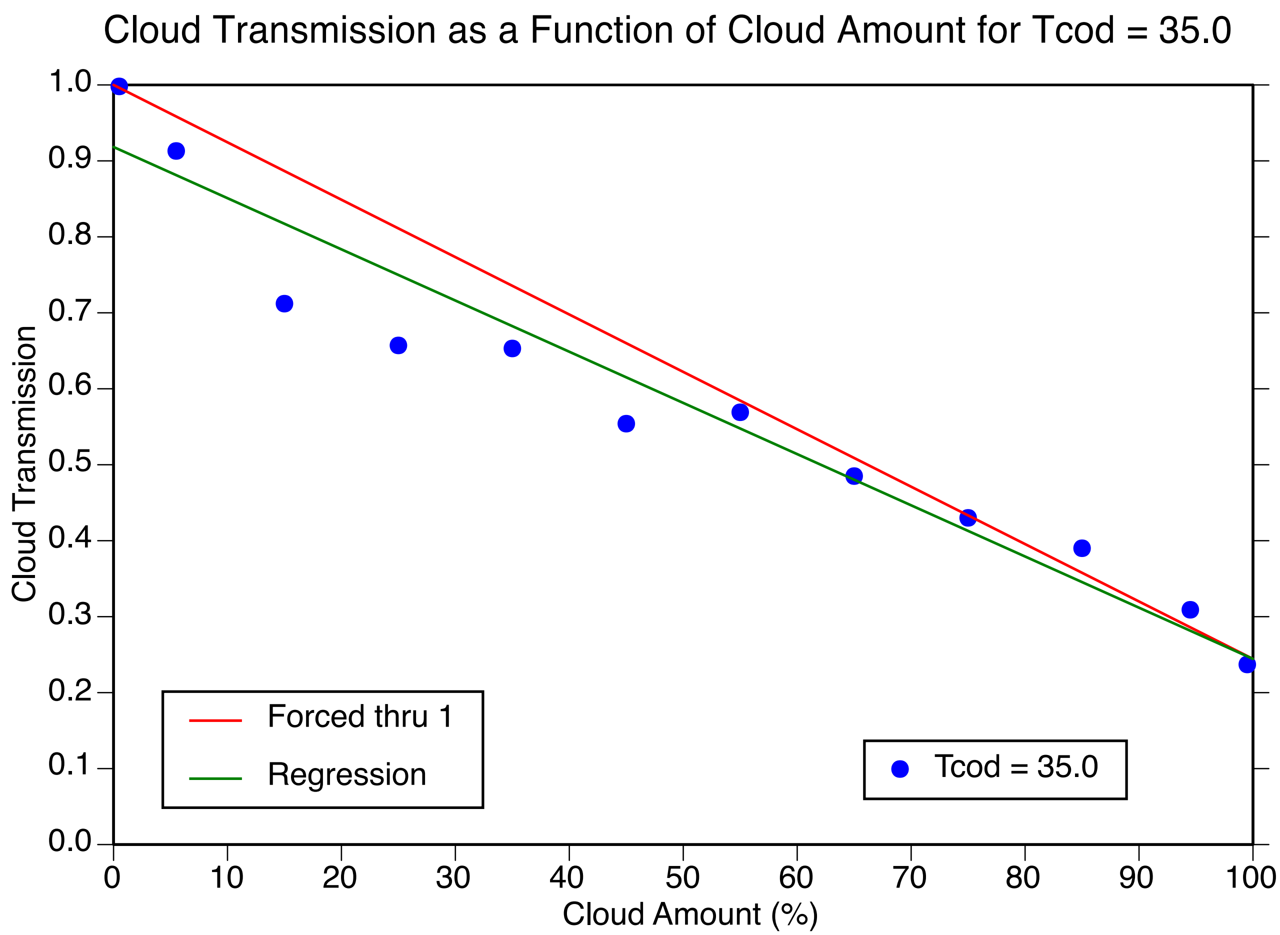

Cloud Transmission as a Function of Cloud Amount for Tcod = 3.5
Cloud Transmission
Cloud Amount (%)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0
10
20
30
40
50
60
70
80
90
100
Forced thru 1
Regression
Tcod = 3.5

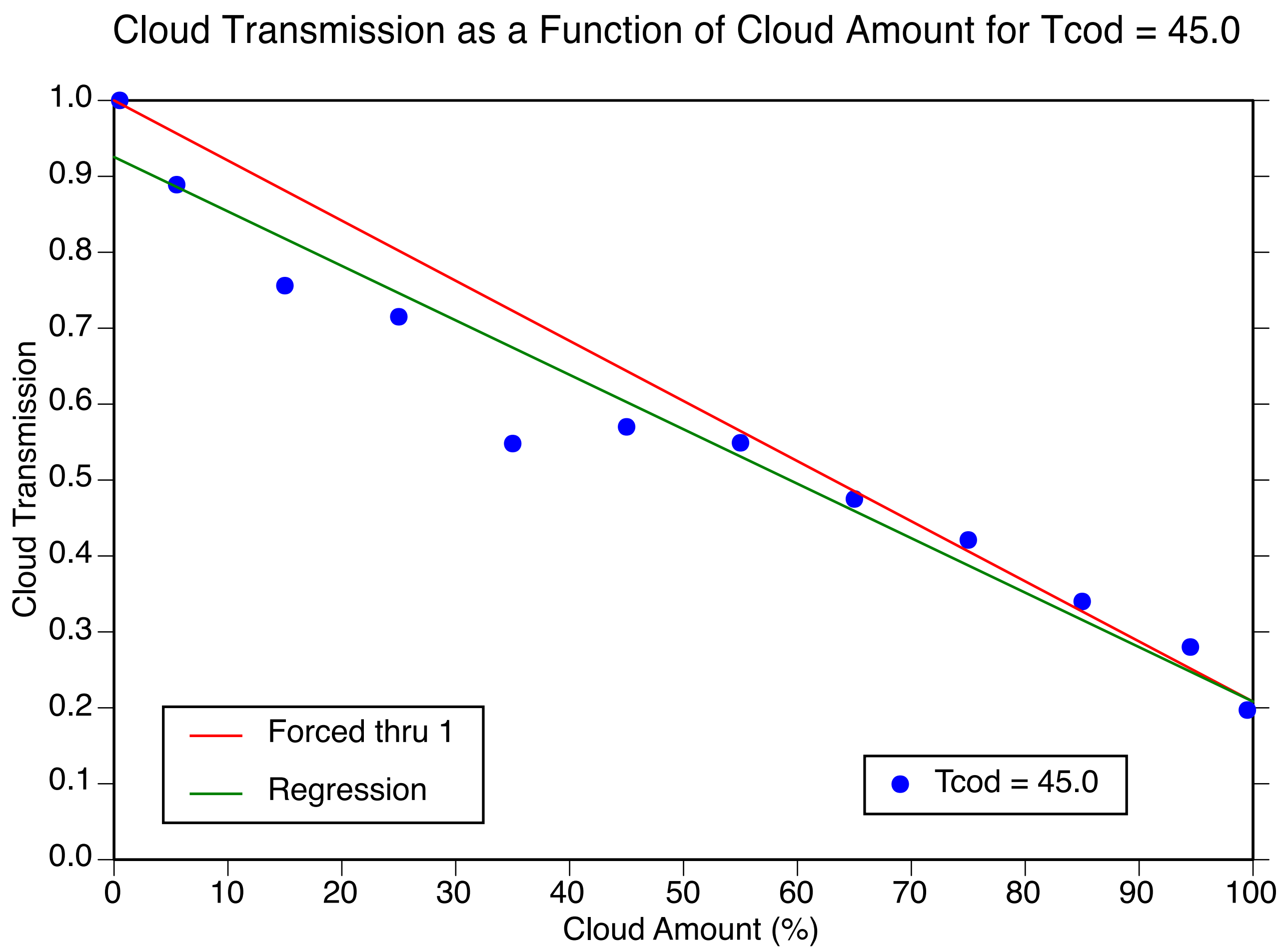

Cloud Transmission as a Function of Cloud Amount for Tcod = 7.5
Cloud Transmission
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
Cloud Amount (%)
Forced thru 1
Regression
Tcod = 7.5

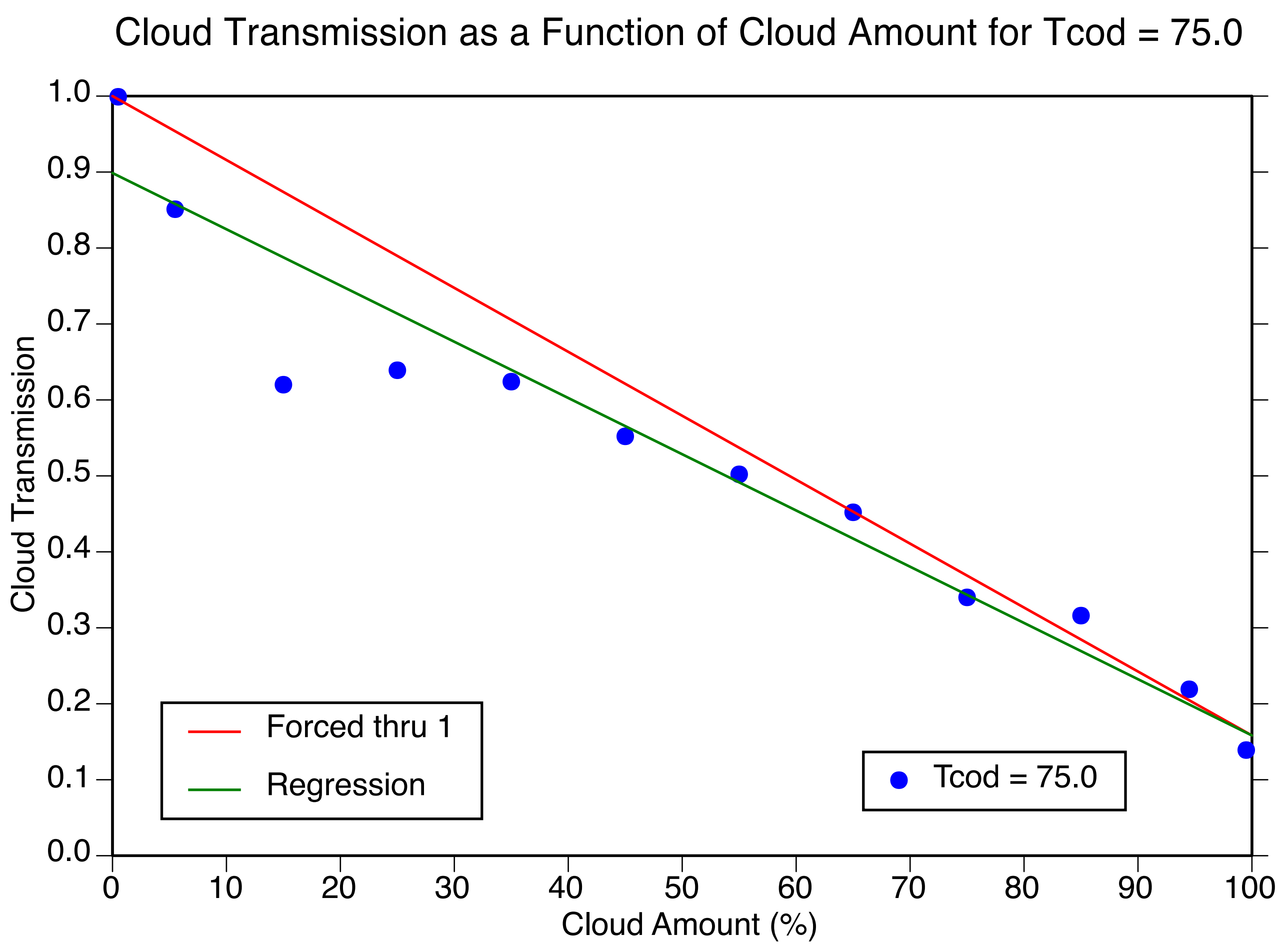


Cloud Transmission as a Function of Cloud Amount for Tcod = 15.0
Cloud Transmission
Cloud Amount (%)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
Forced thru 1
Regression
Tcod = 15.0


Cloud Transmission as a Function of Cloud Amount for Tcod = 25.0
Cloud Transmission
Cloud Amount (%)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
Forced thru 1
Regression
Tcod = 25.0


Cloud Transmission as a Function of Cloud Amount for Tcod = 35.0
Cloud Transmission
Cloud Amount (%)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0
10
20
30
40
50
60
70
80
90
100
Forced thru 1
Regression
Tcod = 35.0


Cloud Transmission as a Function of Cloud Amount for Tcod = 45.0
Cloud Transmission
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
Cloud Amount (%)
Forced thru 1
Regression
Tcod = 45.0



Cloud Transmission as a Function of Cloud Amount for Tcod = 75.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Cloud Transmission
0
10
20
30
40
50
60
70
80
90
100
Cloud Amount (%)
Forced thru 1
Regression
Tcod = 75.0